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J R Yabsley

JONNE YABSLEY
<u>TEAM LEADER EXAMINATION</u>
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ORIGINAL

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Patents Act 1990

PROVISIONAL SPECIFICATION

Invention Title: "Process for the Production of Liquefied Natural Gas"

The invention is described in the following statement:

"Process for the Production of Liquefied Natural Gas"

Field of the Invention

The present invention relates to a process for the production of Liquefied Natural Gas.

Background Art

Traditional processes for the production of liquefied natural gas (hereinafter "LNG") comprise, in broad terms, a natural gas pre-treatment stage and a gas liquefaction stage. The pre-treatment stage is required to remove components of the gas stream that will freeze solid at cryogenic temperatures. Examples of components removed for this reason are carbon dioxide and water. Carbon dioxide is typically removed in an amine and/or membrane process, whilst water is removed in a molecular sieve process. Such pre-treatment may require the gas to be heated to about 50°C.

The liquefaction stage of the process comprises both cryogenic heat exchange and refrigeration. The pre-treatment stage provides 'sweet dry' gas which is passed to a heat exchanger and expansion valve, where it is cooled to about -150°C(depending upon gas composition and storage pressure), liquefied and transferred to storage.

The refrigeration step comprises each of a standard multi-stage compression, cooling by air or water and a staged expander cycle, in which most refrigeration is provided by the isentropic expansion of a recycle stream. A turbo expander-compressor is used to recover power from gas expansion and the refrigerant is further compressed in main gas driven booster compressors. Warm refrigerant is pre-cooled by cold refrigerant gas prior to entering the expander cycle so that the necessary cryogenic temperatures can be achieved.

Typically employed processes for the production of LNG as described above presently have substantial energy requirements for cooling and liquefaction of

[redacted]

the natural gas. This energy is supplied by mechanical drives that use prime movers, such as gas turbines, gas engines and electric motors, to drive compressors for the necessary refrigeration processes. The prime movers are inherently very inefficient and are known to convert only 25 – 40% of the energy supplied as fuel into useful compressive work. The majority of energy is lost to atmosphere in the form of heat. As such, presently available processes for LNG production are very inefficient.

The feed natural gas is typically pre-treated in known LNG processes to remove carbon dioxide and water prior to liquefaction. This pre-treatment requires heating in an amine or membrane system. As a result, further cooling energy is then required to liquefy the natural gas.

The process for the production of liquefied natural gas of the present invention has as one object thereof to overcome substantially the abovementioned problems of the prior art, or to at least provide a useful alternative thereto.

Throughout the specification, unless the context requires otherwise, the word "comprise" or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

The preceding discussion of the background art is intended to facilitate an understanding of the present invention only. It should be appreciated that the discussion is not an acknowledgement or admission that any of the material referred to was part of the common general knowledge in Australia as at the priority date of the application.

Disclosure of the Invention

In accordance with the present invention there is provided a process for the production of liquefied natural gas, the process comprising the steps of:

i) Pre-treatment of a natural gas stream;

ii) Chilling of the resulting pre-treated gas; and

iii) Liquefaction of the pre-treated and chilled gas.

Preferably, the chilling step is driven at least in part by waste heat from the liquefaction step. The waste heat may comprise hot jacket water and/or hot exhaust gases from the main gas engine or turbine driven compressor.

Still preferably, waste heat from the liquefaction step is utilised, at least in part, in the gas pre-treatment step.

The chilling step may further condense certain components of the natural gas stream and/or assist in the pre-treatment step by way of water condensation and/or the condensing/freezing of carbon dioxide.

Further preferably, the chilling step cools the pre-treated gas stream to about 10°C. The pre-treated gas stream may be cooled to about -50°C.

Still further preferably, the chilling step utilises either a lithium bromide or an ammonia absorption chiller.

In one form of the invention a turbo-expander or 'JT' valve is added between the chilling step and the liquefaction step to further cool the natural gas stream.

In accordance with the present invention there is further provided apparatus for the production of liquefied natural gas, the apparatus comprising an amine and/or membrane package for carbon dioxide removal, a dehydration package for water removal, a liquefaction package, a chiller and at least one refrigerant compressor package, the chiller being arranged so as to chill the natural gas stream to be liquefied.

In one form of the invention the liquefaction package further comprises the chiller arranged to chill a pre-treated natural gas stream from the amine and

[redacted]

dehydration packages prior to passing that gas stream to a cryogenic heat exchanger.

In another form of the present invention the chiller is located before, or as a part of , the amine and/or membrane packages so as to assist in pre-treatment of the natural gas stream.

Preferably, the chiller is driven by waste heat from the or each refrigerant compressor packages. This waste heat may also be directed to the amine package for amine regeneration and/or to the dehydration package for regeneration of molecular sieves used therein.

The chiller may be provided in the form of either an ammonia or lithium bromide absorption chiller. The ammonia absorption chiller preferably cools the gas stream to about –30 to -50°C whereas the lithium bromide absorption chiller cools the gas stream to about 0 to 10°C.

A turbo-expander or "JT" valve may be added downstream of the chiller.

In accordance with the present invention there is still further provided a refrigeration process in which waste heat is utilised to precool a process stream thereby reducing the refrigeration load.

In one form of the present invention the refrigeration process is utilised in an air separation plant. In a further form of the invention the refrigeration process is employed in an LPG extraction process.

Brief Description of the Drawings

The present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:-

Figure 1 is a schematic flow chart of a process for the production of liquefied natural gas in accordance with the present invention;

[redacted]

Figure 2 is a schematic representation of the process of Figure 1;

Figure 3 is a pressure enthalpy diagram for the process of the present invention when the chilling step cools the natural gas stream to about 10°C; and

Figure 4 is a pressure enthalpy diagram for the process of the present invention in which the chilling step cools the natural gas stream to a temperature of about -50°C, after which an expander or "JT" valve further precools the natural gas stream.

Best Mode(s) for Carrying Out the Invention

In Figure 1 there is shown a process 10 for the production of liquefied natural gas in accordance with the present invention. The process 10 broadly comprises passing a natural gas feed gas 12 to a gas pre-treatment step 14, after which the gas stream is passed to a chiller 16. The chiller 16 cools the gas stream to at least about 10°C prior to the gas stream passing to a liquefaction stage 18, finally producing a liquefied natural gas ("LNG") product 20.

As shown in Figure 1, waste heat from the liquefaction stage 18 is utilised by both the chiller 16 and the pre-treatment step 14.

In Figure 2 there are shown the process 10 in greater detail than that of Figure 1.

The natural gas stream 12 is subjected to a pre-treatment step 14 comprising an amine package 22 and a dehydration package 24. The amine package 22 and the dehydration package 24 remove carbon dioxide and water from the natural gas stream 12 respectively. Broadly speaking, the pre-treatment step 14 is required to remove components in the natural gas stream 12 that would otherwise freeze at cryogenic temperatures experienced in the liquefaction step 18. The pre-treatment step 14 normally requires the natural gas stream 12 to be heated to about 50°C. As such, this step demands more cooling and more

energy to ultimately reach liquefaction temperature in the subsequent liquefaction step 18.

The liquefaction step 18 comprises at least the majority of a liquefaction package 26 shown in Figure 2, the liquefaction package 26 comprising a main cryogenic heat exchanger 28 and one or more expander compressors 30 together with a refrigeration cycle 32. The refrigeration cycle 32 further comprises one or more refrigerant compressor packages 34.

The liquefaction package 18 provides LNG that is passed to one or more LNG tanks 36.

The sweet dry natural gas produced by the pre-treatment step 14 passes through the heat exchanger 28 and an expansion valve 38, where it is cooled to around -150°C and liquefied prior to passing to the LNG tanks 36. The refrigeration cycle 32 comprises a multi-stage compression, air or water cooling and expander cycle, with most refrigeration produced by isentropic expansion of a recycle stream. Power from gas expansion is recovered in a turbo expander-compressor and the refrigerant is further compressed in the main gas engine or turbine driven booster compressors. Warm refrigerant is precooled by cold refrigerant gas prior to entering the expander so that the required cryogenic temperature in the heat exchanger 28 can be achieved.

The chiller 16 is provided in-line between, or upstream of, the pre-treatment step 14 and the liquefaction package 18. The chilling step 16 may be achieved by either of a lithium bromide absorption chiller, cooling the natural gas stream to about 10°C, or an ammonia absorption chiller, cooling the natural gas to about -50°C. This chilling of the natural gas stream prior to the heat exchanger 28 reduces significantly the load on the liquefier/refrigeration plant by, in the experience of the applicants, as much as 50% compared with the prior art.

The chiller step 16 utilises hot jacket water and/or hot exhaust gases from the main gas engine compressor drives. This heating system may also be used to regenerate the amine and/or preheat the natural gas stream prior to entering

membranes and/or heat regeneration gas required for the molecular sieves of the dehydration package 24. Hot dry refrigerant gas from the compressor discharge may also be used to regenerate the molecular sieves of the dehydration package 24, prior to that same gas being used as fuel for the compressor drives 34.

It is also understood that, dependent upon the composition of the natural gas stream 12, another benefit of the process 10 of the present invention is that the chilling step 16 may condense some components, including heavy hydrocarbons, LPG's, water and/or carbon dioxide. These condensed components can either be a useful product stream or may assist in the pre-treatment process itself.

In Figure 3 there is shown a pressure enthalpy diagram for the process 10 of the present invention utilising a lithium bromide absorption chiller cooling the natural gas stream to about 10°C. In Figure 4 there is shown the same process 10 in which an ammonia absorption chiller is utilised, cooling the natural gas stream to about -50°C, followed by an expander or "JT" valve 38, as shown in Figure 2, to further pre cool the natural gas stream.

The process 10 of the present invention for the production of LNG utilises waste heat from the refrigeration cycle to generate heat or cold as required, thereby increasing the efficiency of the LNG production process when compared with prior art processes. For example, prior art LNG processes lose energy by way of waste heat to atmosphere. The present invention utilises waste heat to precool gas and reduce refrigeration load, thereby improving the efficiency of the process and reducing capital and operating costs.

It is envisaged that the process of the present invention may be applied to air separation plants and LPG extraction processes, thereby providing similar benefits with regard to utilisation of waste heat. Each of these processes require refrigeration and waste heat can again be utilised to precool the stream and reduce the refrigeration load thereby improving efficiency and reducing costs.

[redacted]

Modifications and variations such as would be apparent to the skilled addressee are considered for within the scope of the present invention.

Dated this Twenty Second day of January 2003.

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Perth, Western Australia
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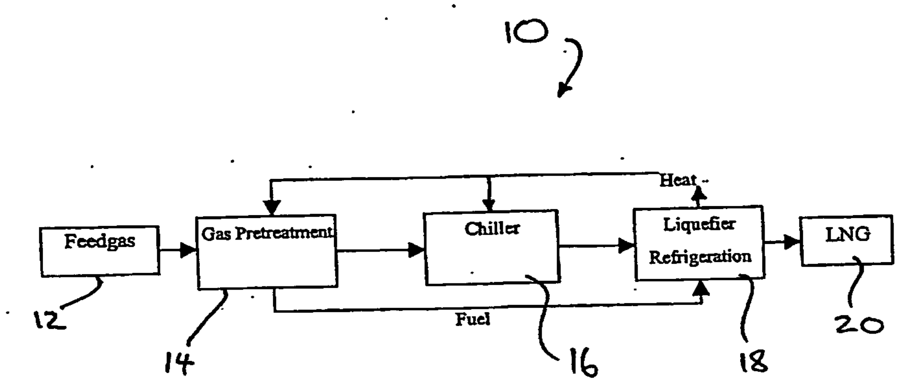
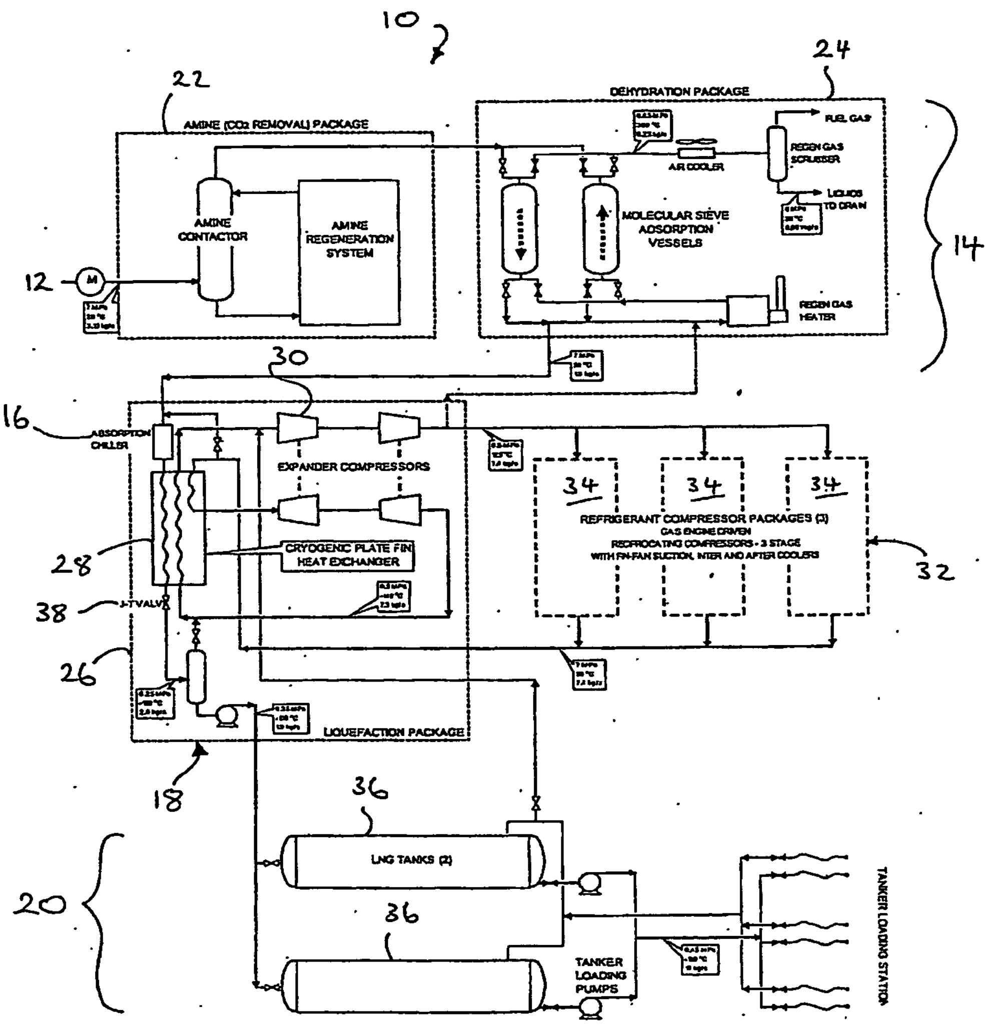

10
Heat
Feedgas
Gas Pretreatment
Chiller
Liquefier
Refrigeration
LNG
Fuel
12
14
16
18
20

Figure 1


10
22
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36
AMINE (CO2 REMOVAL) PACKAGE
AMINE CONTACTOR
AMINE REGENERATION SYSTEM
DEHYDRATION PACKAGE
FUEL GAS
REGEN GAS SCRUBBER
LIQUIDS TO DRAIN
AIR COOLER
MOLECULAR SIEVE ADSORPTION VESSELS
REGEN GAS HEATER
ABSORPTION CHILLER
EXPANDER COMPRESSORS
CRYOGENIC PLATE FIN HEAT EXCHANGER
J-T VALVE
LIQUEFACTION PACKAGE
REFRIGERANT COMPRESSOR PACKAGES (3)
GAS ENGINE DRIVEN
RECIPROCATING COMPRESSORS - 3 STAGE
WITH FIN-FAN SUCTION, INTER AND AFTER COOLERS
LNG TANKS (2)
TANKER LOADING PUMPS
TANKER LOADING STATION

Figure 2

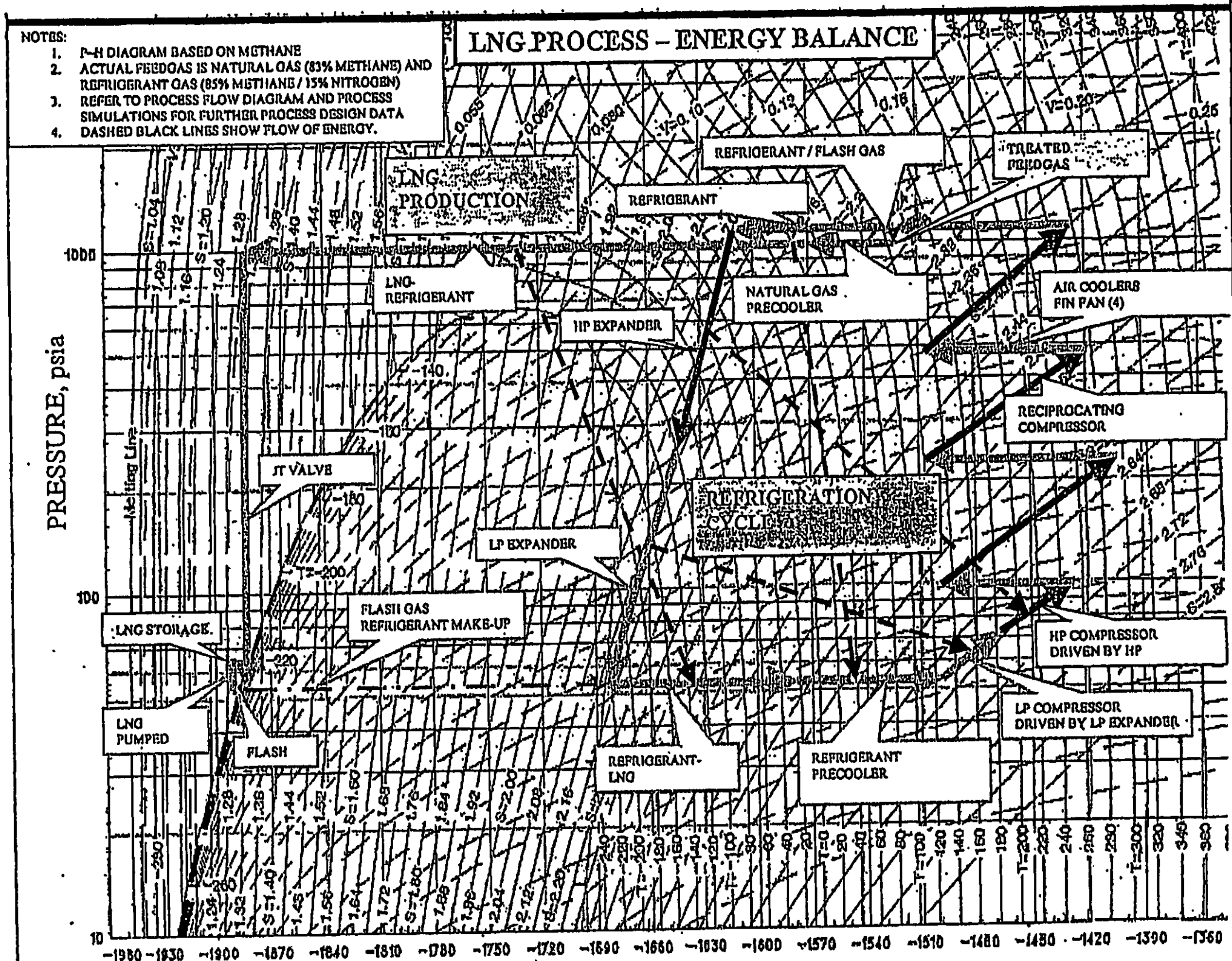

Figure 3 ENTHALPY Btu/lb

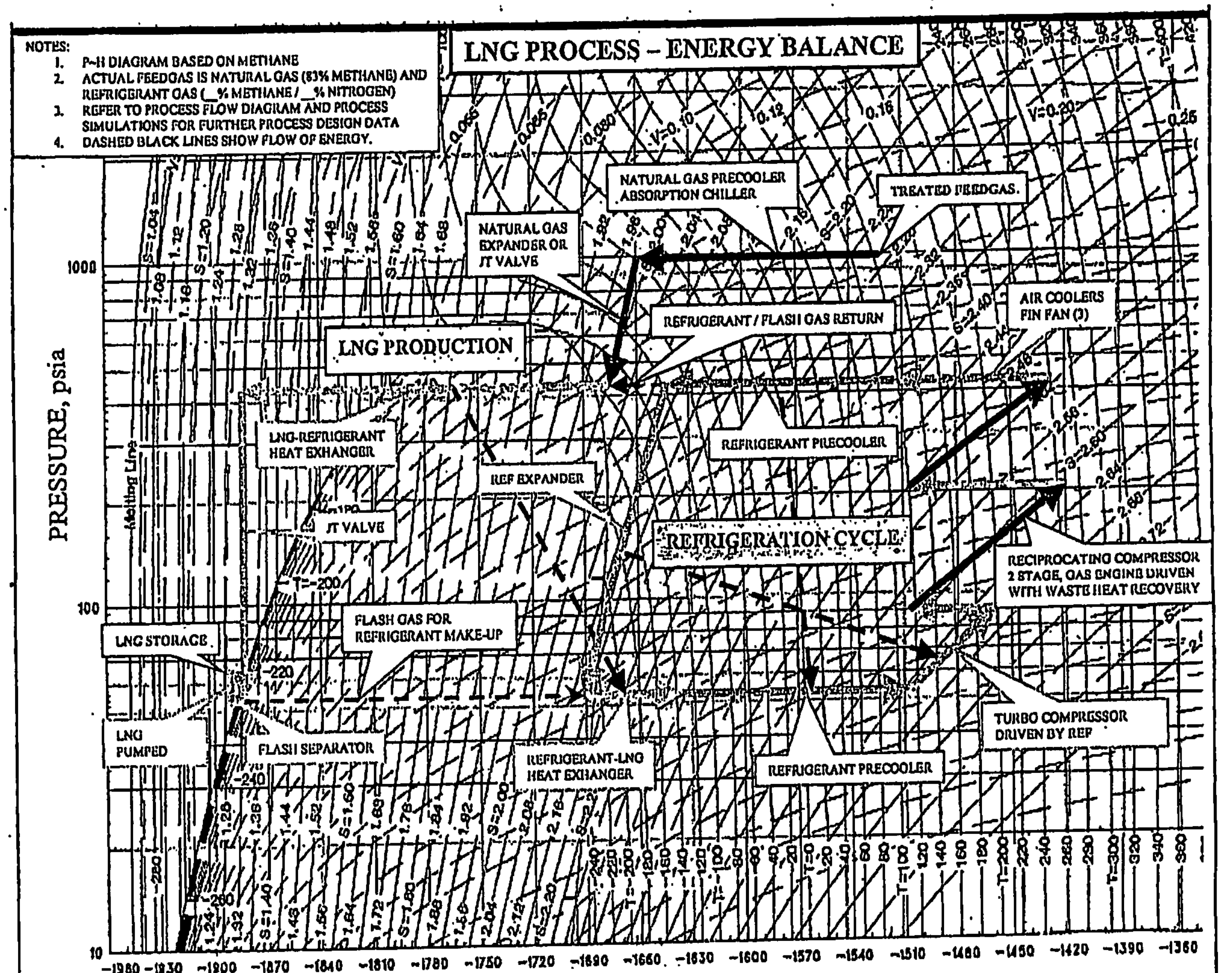

Figure 4 ENTHALPY Btu/lb